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DIVISION - THE AVIATION CORPORATION
WILLIAMSPORT, 38, PENNA.

INVESTIGATION OF SEVERAL METHODS OF
FUEL INTRODUCTION TO THE 70727 REED
VALVE COMBUSTION CHAMBER
Section I - Item 3, Contract NOa(s)-4718

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REPORT NO. 1114

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Dates of Tests:


March 3 through 19 and
April 9 through 18, 1947.

Date of Report:


May 15, 1947

INVESTIGATION OF SEVERAL METHODS OF
FUEL INTRODUCTION TO THE 70727 REED
VALVE COMBUSTION CHAMBER.
Section I - Item 3, Contract NOa(s) 4718

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A P P E N D I X

Copies of Log Sheets pages 155 through 161, 181 through
185, 187 through 190 are included in the Experimental
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INVESTIGATION OF SEVERAL METHODS OF FUEL INTRODUCTION
TO THE 70727 REED VALVE COMBUSTION CHAMBER.OBJECT:

1. The object of this investigation was to explore several means of fuel introduction in an effort to improve the performance of the 70727 reed valve combustion chamber.

SUMMARY:

2. This investigation is a continuation of the preliminary overall survey of ways to improve the performance of the subject type of combustion chamber. The tests, which were of an informal nature, were particularly aimed at determining what means of fuel introduction would show possibilities for further investigation.

3. The best means of fuel introduction of those tried was found to be injection through several small jets into high velocity air streams inside the chamber which was supplied from a high pressure source other than the combustion air. The various ways of "solid" fuel injection tried in this investigation did not show up as well as the above. Introduction of the fuel into the intake manifold, before the reed valves, proved unsuccessful.

CONCLUSIONS:

4. It is concluded that with the particular parts and modifications tested:

- a) The revised 70920 air fuel injector assembly produced the best performance.

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- b) A single 50° or 45° included spray angle Bosch nozzle located in the front end of the chamber was next best to the 70920 nozzle.
- c) Two 50° Bosch nozzles diametrically opposite in the chamber were inferior to the above.
- d) The two diametrically opposite jets spraying forward in the chamber were unsatisfactory.
- e) Introduction of the fuel into the air by means of a manifold spray ring at the entrance to 9 of the reed valves was not satisfactory.

RECOMMENDATIONS:

5. It is recommended that sufficient injection equipment be provided to permit a further, more thorough investigation of fuel introduction.

DESCRIPTION:

6. Reference is made to report No. 1097 entitled - "Initial Test of the Multi Reed Valve Combustion Chamber", for a detailed description of the 70727 reed valve combustion chamber.

7. Print No. 70920 on page 8 shows the assembly details of the air fuel injector assembly. This assembly was finally altered by brazing a 5/16" O.D. washer on the tip of the stem and drilling out the four jet holes to .031" diameter. The sketch on page 9 shows the installation of the 70920 assembly in the reed valve combustion chamber.

8. The sketch on page 10 shows the position of the single 50° or 45° included spray angle Bosch fuel nozzle in the front end of the chamber.

9. The location of the two 50° Bosch nozzles mounted diametrically opposite in the chamber wall are shown by the sketch on page 11.

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10. The sketch on page 12 shows the location and direction of spray of the two diametrically opposite fuel spray jets. These jets were made in the form of tips to screw on the ends of the Bosch nozzles (which acted as check valves). The tips had two .031" diameter holes drilled in one side so that the resulting jets converged about 1 1/2 inches away from the tip. The overall spray was at an angle of about 30° with the axis of the chamber. The two tips were located so that they sprayed forward, converging about three inches upstream.

11. The manifold spray ring consisted of a 1/4" copper tube manifold with nine 1/8" copper tube jets soldered to the manifold. This assembly was positioned as shown by the sketch on page 13 so that the jets impinge on the reeds at about the center from the upstream side.

12. Both the 70862 fuel screen and the sleeve type heater basket described in report No. 1056 on the rotary sleeve valve combustion chamber were used briefly.

METHOD OF TEST:

13. By reason of the many variables touched upon and the generally negative nature of the performance, the procedure for making the subject investigation was largely dictated by the behavior of the reed valve unit with the particular variation under consideration.

14. With each variation explained in the description, a preliminary qualitative spot check was made at 900 cpm and 20 psi ram (selected as a convenient basis of comparison with previous data). If good performance or performance better than any observed during the investigation was obtained, readings were taken over the operatable fuel flow range.

15. For all phases of this investigation, fuel was supplied by two EBN 7645 Bosch fuel injector pumps which were coupled in parallel

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and delivered to the particular fuel introducing modification being tested. This is identically the same system as used with previous tests.

RESULTS:

16. The qualitative and quantitative results of the subject investigation are recorded on log sheets Nos. 155 through 161 and 181 through 185, and 187 through 190. Prints of these log sheets are included with the Experimental File copies of this report only. Dates of test were March 19th through 27th and April 9th through 18th, 1947.

17. Curve No. 7557, page 14, a plot of thrust vs air fuel ratio and curve No. 7558 on page 15, a plot of specific thrust vs air fuel ratio are comparisons of the 70920 air fuel injection assembly with the 50° included spray angle Bosch "solid injection" nozzle. Both plots show better performance with the 70920 assembly.

18. Curve No. 7559, page 16, and No. 7560, page 17, which are plots of thrust and specific thrust respectively vs air fuel ratio show a comparison of operation with and without the sleeve type heater basket when using the 70920 air fuel injection assembly. Performance was found to be better without this type of heater basket.

19. Following is a summary tabulation of the qualitative results obtained:

Means of Fuel Introduction

1. 70920 air fuel injector assembly and variations.

Performance Characteristics

As received, the 70920 assembly performance was unsatisfactory. When using a 5/16" diameter washer brazed on the end of the 70919 fuel line assembly, best operation of any was obtained, with the 70920 assembly projecting into the

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Means of Fuel IntroductionPerformance Characteristics

- | | |
|--|--|
| II. Manifold spray ring (introduction of fuel just upstream of reeds). | chamber up to about 1". No improvement observed with sleeve type heater basket. |
| III. Two 50° included spray angle Bosch nozzles diametrically opposite in front plug belt. | Only constant burning was possible with poor thrust. Fuel flow range was narrow and operation caused ram air pressure to be erratic. Unit was difficult to start. |
| IV. Two spray tips spraying upstream at about 30° angle, located diametrically opposite in both front and rear plug belts. | Unit functioned properly, but thrust and mean pressures were about 20% lower than the best with the 70920 assembly. |
| V. Bosch nozzle having 45° or 50° included spray angle located in front end of the chamber. | Front plug belt location best. Fuel flow range very narrow, the flow being relatively small. Thrust and mean pressures somewhat better than with the two 50° nozzles. Sleeve type heater basket did not improve operation. |
| | A single "solid" fuel injection nozzle gave next best performance to the 70920 assembly. Speed and fuel flow ranges were good. Sleeve type heater basket did not improve performance. |

DISCUSSION:

20. The reasons for the superiority of the 70920 air fuel injector assembly over any form of "solid" fuel injection so far tried are not clear. Apparently some advantage is gained when a high velocity air stream is used to atomize the fuel rather than to depend on "solid" injection alone for atomization and dispersion.

21. The 70920 air fuel injector assembly requires over 70 psi air pressure to operate satisfactorily. Dependent upon the application of the reed valve unit, this pressure may be difficult to obtain. However, it possibly could be solved with other designs utilizing the same principle,

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but with lower pressure air or by making use of the pressure generated by the combustion.

22. In addition to the above, the possibility of some form of "solid" fuel injection being developed to produce as good or better results than the 70920 type of injector would be desirable from the standpoint of simplicity and should be investigated.

23. In the course of other investigation where chamber extensions were used (separately reported) and with which solid injection was employed, it was observed that some of the fuel charge injected collected on the chamber walls, ran down the bottom of the chamber and was able to seep out at the loose flange threads at the rear end before it had been completely burned. This indicates the forms of "solid" fuel injection used to date are relatively poor in that atomization and mixing of the fuel with the air is not anywhere near as good as is believed possible.

24. Among the several attempts made in this investigation to overcome the above situation were cross chamber fuel injection and injection of the fuel forward and opposite to the direction of the incoming air charge. The theory was that by giving the fuel a velocity either at right angles or opposite to the velocity of the air better and faster atomization and mixing would occur. It is believed that the reason for the poor showing of these attempts was that, as with other forms of "solid" fuel injection, the fuel penetrated to the chamber walls and collected there before atomization and mixing would occur.

25. Introduction of the fuel into the air stream in the intake manifold just before entering the reed valves was tried partly in an effort to provide more time for atomization of the fuel and mixing with

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the air before combustion took place. Insufficient work has been done on this to determine if the negative performance of this method can be overcome.

26. The fuel screen and heater basket were found to be of no benefit. Probably a big factor in this is that atomization and mixing with the subject means of fuel introduction were too poor to begin with.

70920

70920

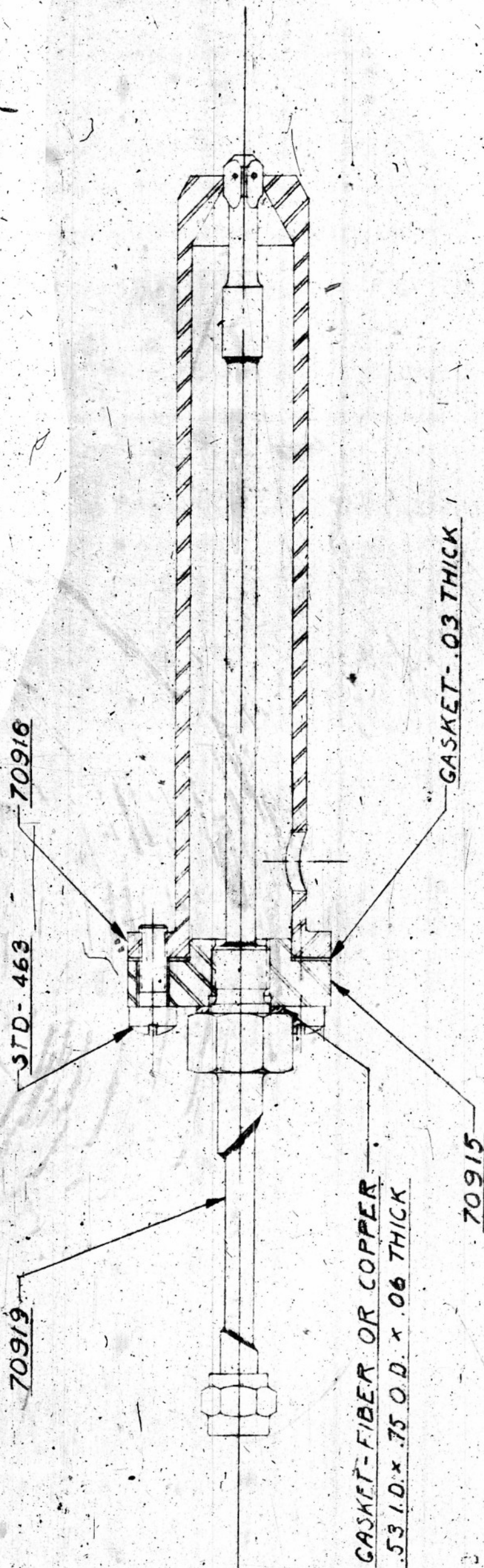
ALTERATIONS

DATE BY

REV. NO.

REV. NO.

17 Pages, Page 8
Report 1114



NOTES

DRAWN	CHKD	APP'D	REV	DATE	UNLESS OTHERWISE SPECIFIED
TRACED					BREAK SHARP EDGES .015
CHECKED					APPROXIMATE RADIUS
STRESS					ALLOWABLE TOLERANCE ON
CF DET.					ANGULAR DIMENSIONS .5°
CF DP					ALLOWABLE TOLERANCE ON
FROM ENG					POORINGS IS ± .05 .00
PROD ENG					ALLOWABLE TOLERANCE ON
OF ENG					CASTINGS IS ± .03
					ALLOWABLE TOLERANCE ON
					FINISHED DIMENSIONS IS ± .01

INJECTOR ASSY - AIR-FUEL

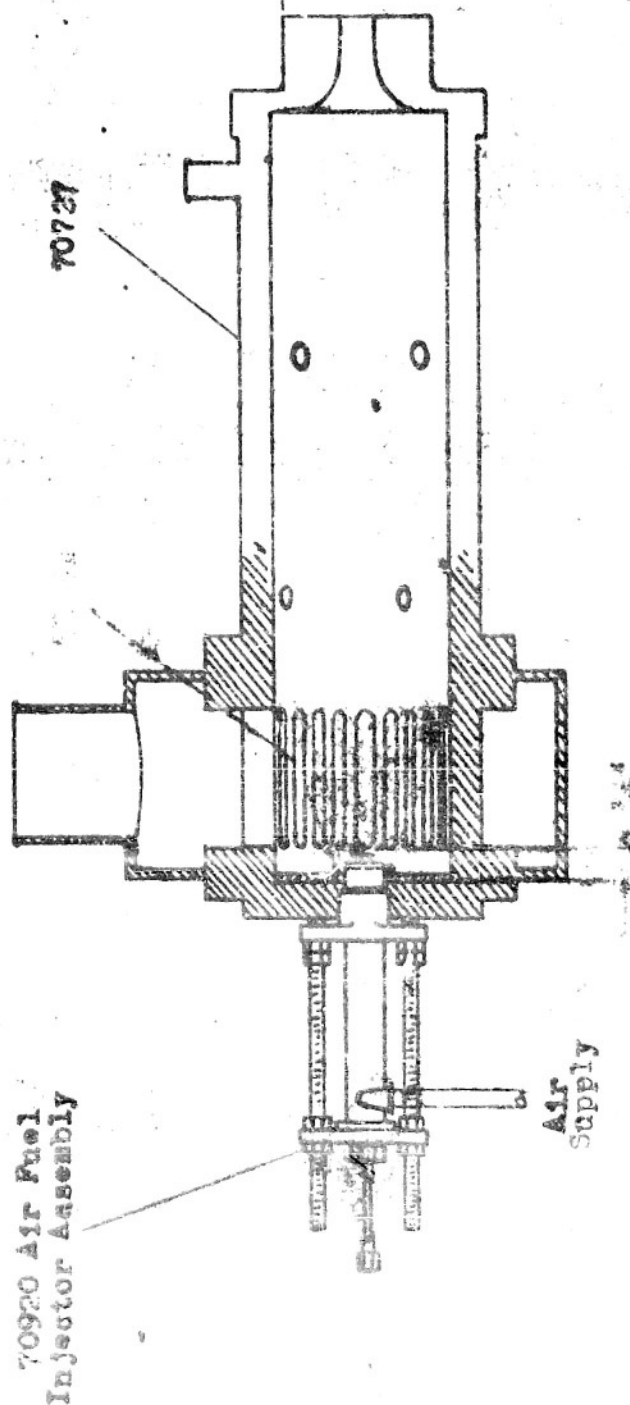
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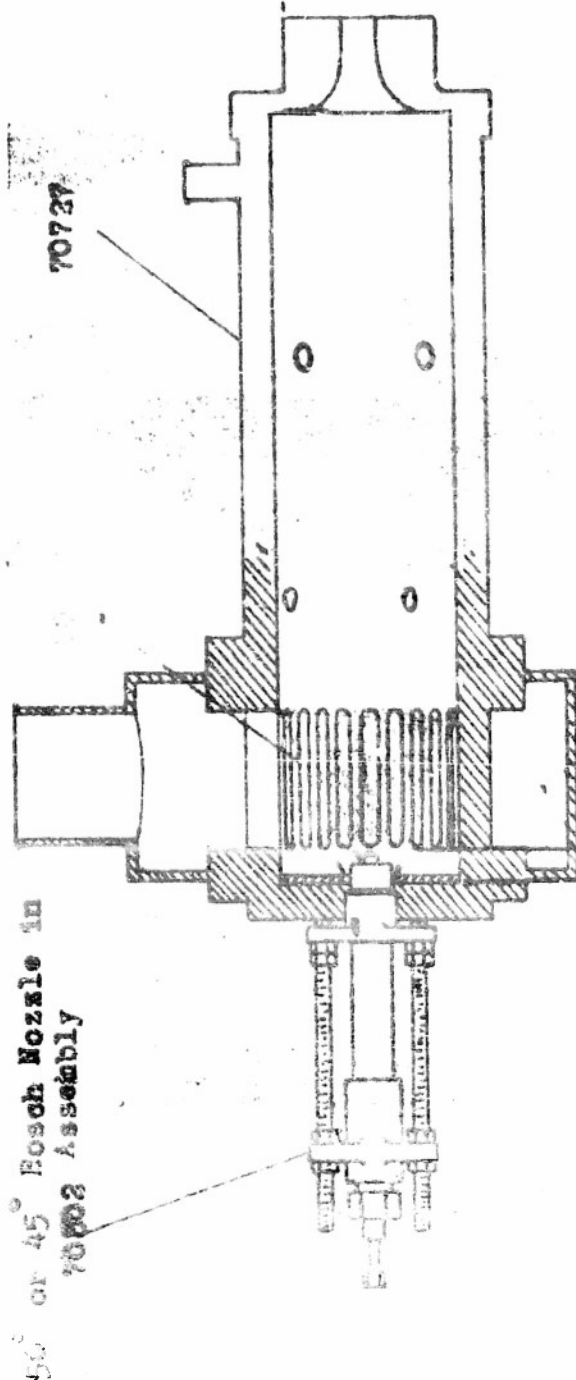
Location of 70920 Air Fuel Injector Assembly in Front of
70727 Reed Valve Combustion Chamber



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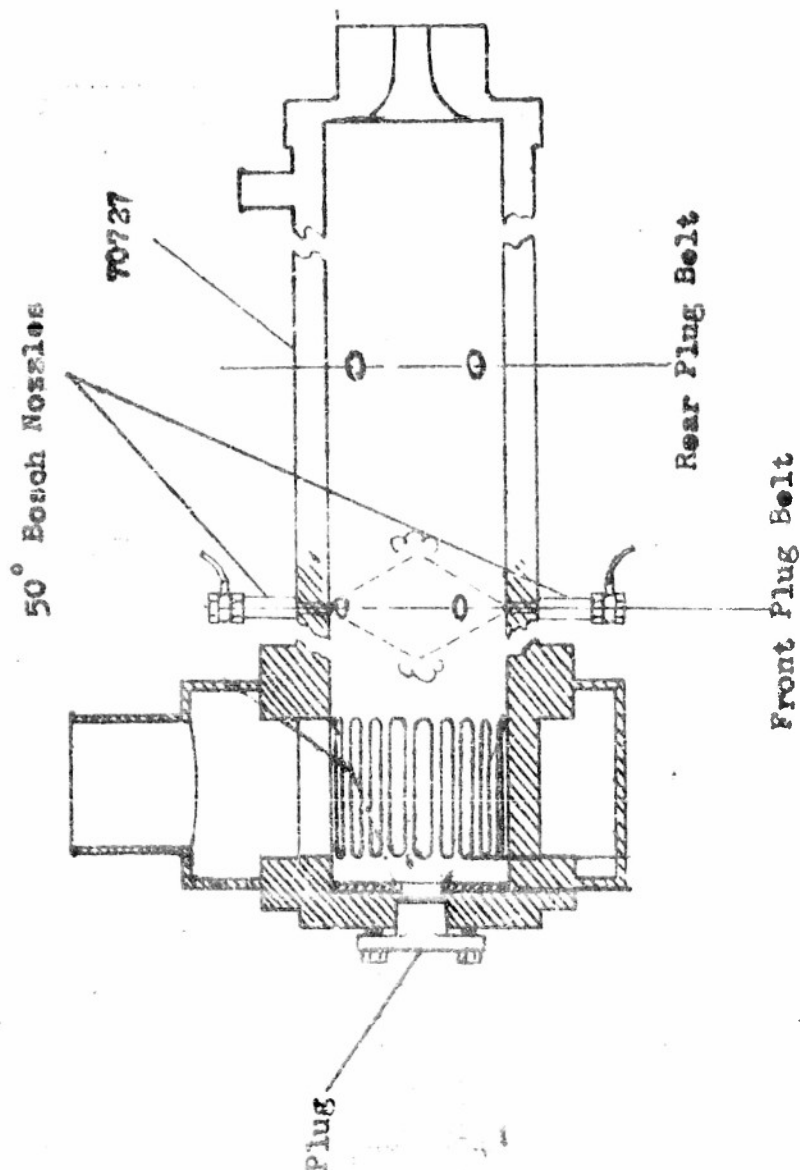
Location of 50° or 45° Bosch Fuel Nozzles in Front of
70737 Reed Valve Combustion Chamber



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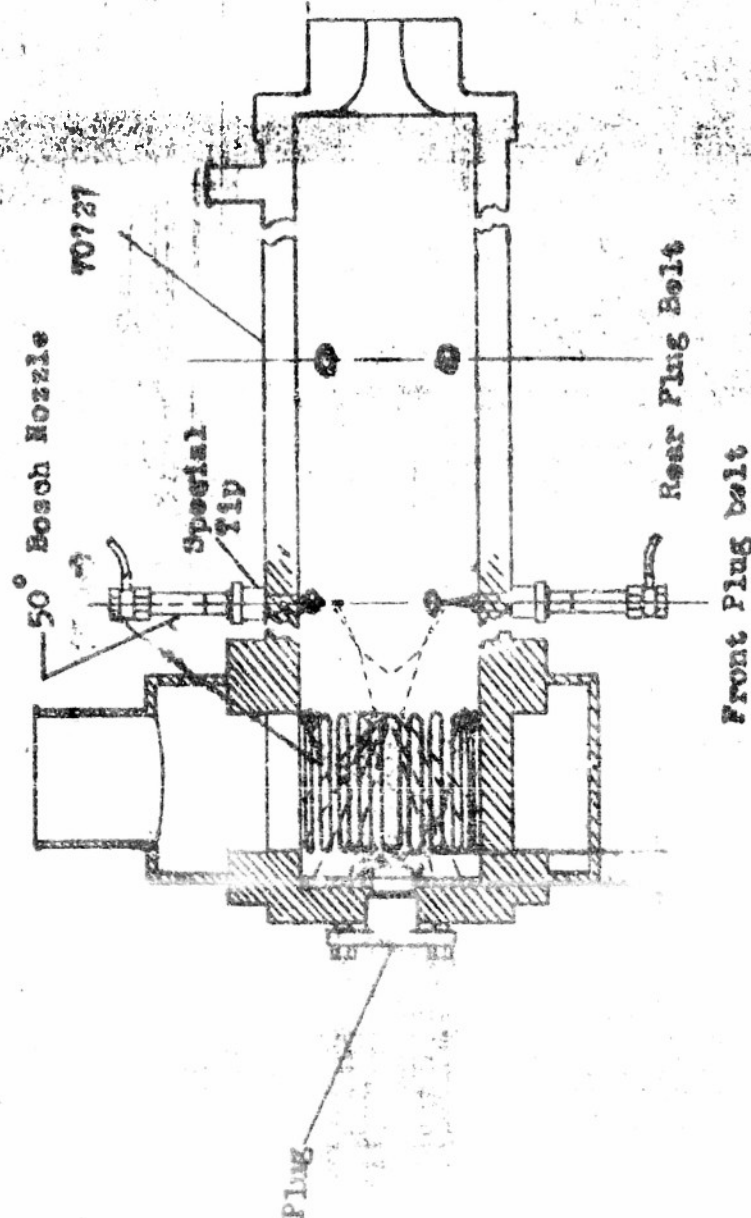
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Location of Two 50° Bosch Fuel Nozzles Diametrically Opposite
in 70727 Reed Valve Combustion Chamber



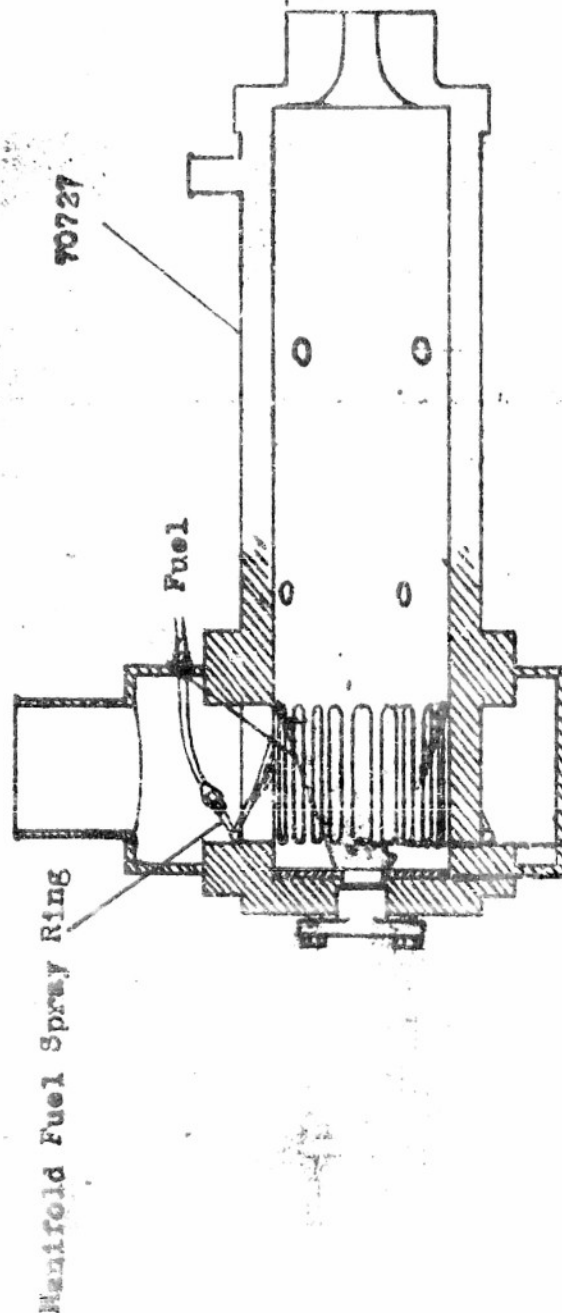
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Location of Two Special Upstream Spray Tips Diametrically Opposite
in 70727 Reed Valve Combustion Chamber

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THE UNIVERSITY OF CHICAGO



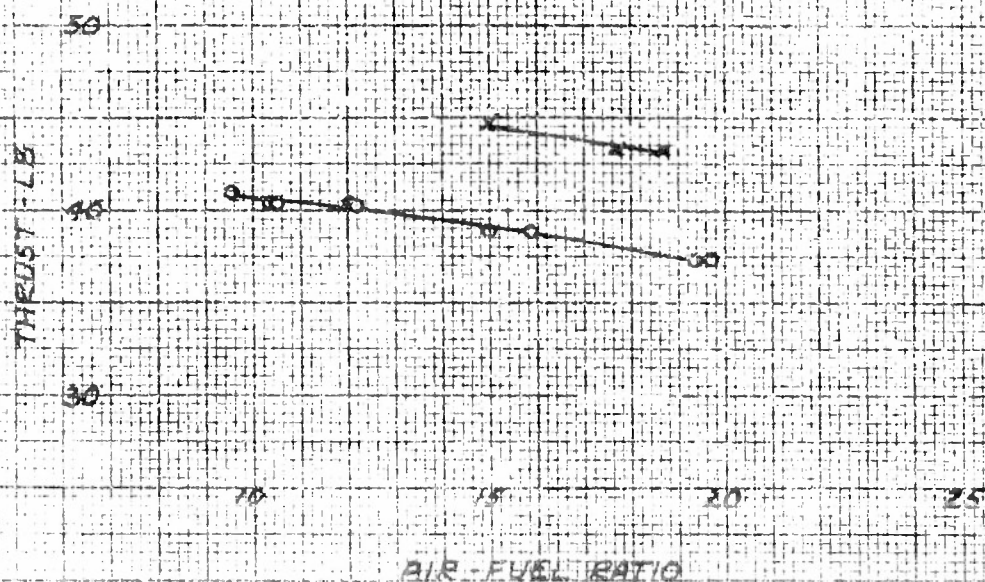
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REPORT NO. 1114
CURVE NO. 7557

REED VALVE COMBUSTION CHAMBER THRUST VS AIR FUEL RATIO

437 CU IN. CHAMB VOL
1.040 IN. DIA EXH ORIFICE
900 RPM
20 PSI RAM

○ BOSCH 50° NOZZLE IN FRONT RUNS 389-797, MARCH 19, 1947
* 70920 AIR FUEL INJECTOR RUNS 917-919, APRIL 18, 1947



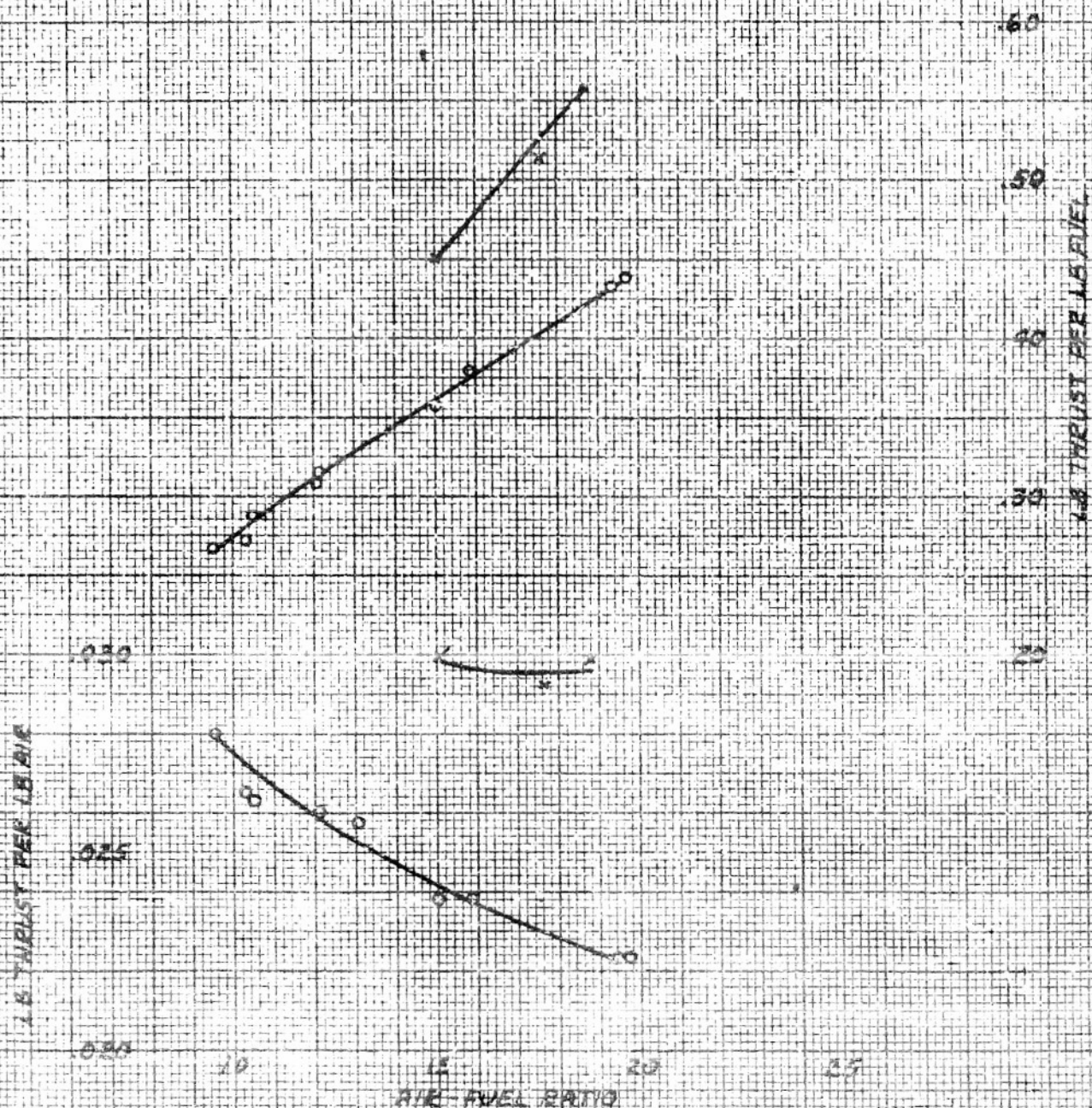
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REPORT NO. 1114
CURVE NO. 7558

REED VALVE COMBUSTION CHAMBER SPECIFIC THRUST vs AIR FUEL RATIO

437 CC IN CYLINDER VOL
1.000 IN DIA EXH ORIFICE
700 RPM
25 PSI RAN

O BENCH FOR NOZZLE W/ FEINT. RUNS 789-797, MARCH 10, 1947
X 70920 AIR FUEL INJECTOR. RUNS 917-919, APRIL 13, 1947



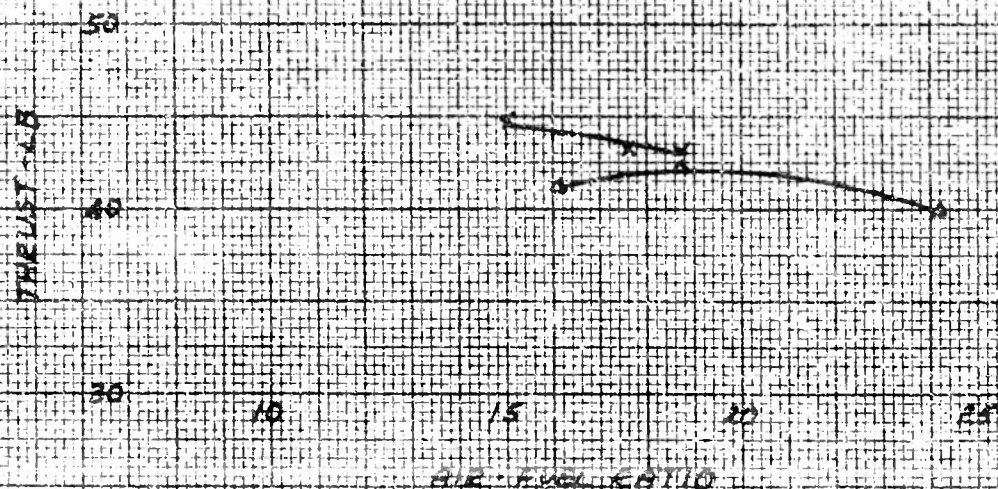
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REPORT NO. 1114
CURVE NO. 7559

REED VALVE COMBUSTION CHAMBER THRUST VS AIR FUEL RATIO

437 CC IN. CHAMB VOL
1.050 IN. DIA EXH ORIFICE
900 RPM
25.751 RPM
70920 A/F FUEL INJECTOR

X WITHOUT SLEEVE TYPE HEATER BASKET RUNS 917-919, APRIL 18, 1947
Δ WITH SLEEVE TYPE HEATER BASKET RUNS 914-916, APRIL 18, 1947



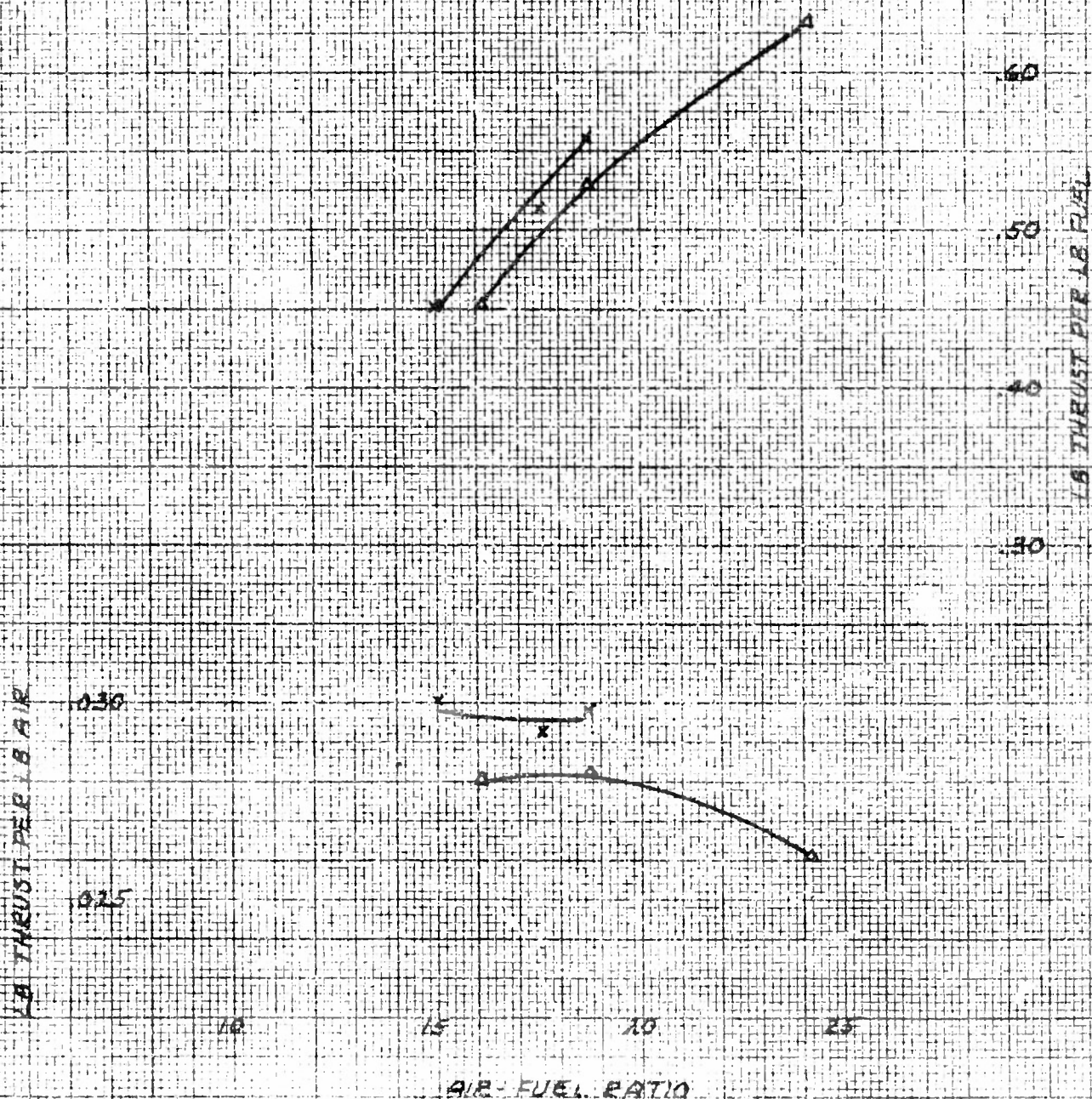
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REPORT NO. 1114
CURVE NO. 7560

REED VALVE COMBUSTION CHAMBER SPECIFIC THRUST vs AIR FUEL RATIO

437 CU IN. CHAMB VOL
1.060 IN DIA EXH ORIFICE
900 RPM
20 PSI BAR
70920 AIR FUEL INJECTOR

X WITHOUT SLEEVE TYPE HEATER BASKET RUNS 917-919, APRIL 18, 1947
Δ WITH SLEEVE TYPE HEATER BASKET RUNS 918-916, APRIL 18, 1947



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